An AI enabled algorithm for detecting excessive and abnormal brain cell activity for Epilepsy attack

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***Abstract* :** Epilepsy harms lives of suffering patients and their families. In some cases, we can detect with analysis, predict and avoid it. Epilepsy varies from a brief loss of awareness to longer periods of a loss of sense combined by the muscle stiffening and jerking. General symptoms of epilepsy are unresponsive and uncontrollable movements such as repetitive jerking, loss of consciousness which might include loss of bowel or bladder control and unusual behaviour such as continuous mood swings.

Internet of Things (IoT) has been growing rapidly due to recent advancements in communications and sensor technologies. Interfacing an every object together through internet looks very difficult, but within a frame of time Internet of Things will change the it in the data . The enormous data captured by the Internet of Things (IoT) are considered of high business as well as social values and extracting hidden information from raw data, various data mining algorithm can be applied to IoT data. In this paper, We use iot device as data capturing device for EEG signals, which will be further processed with ML algorithm from EEG signals.

Preprocessing of EEG signals for noise removal and features extraction are two major issues that have an adverse effect on both anticipation time and true positive prediction rate. To recover it, we have proposed HHT (hilbert-Huang Transform) for preprocessing in less time for signals and min-max classification will be performed for data classification. The parameter to evaluate results of prediction are time and sensitivity.

***IndexTerms* – Epilepsy Attack, Arduino ESP8266, Deep neural network(DNN), Sensors.**

I. INTRODUCTION

In the older times,it was very difficult to control the neurological dieases, moreover, neurological stroke had no identification. So many had to leave their life in darkness. As soon as the time passed, Many new technologies came into exisistence and if we talk about the modern times then numerous technological devices are available regarding cronical dieases of neurology

For example , Deep brain stimulator(DBS), a widely used and comprehensively acknowledged restorative methodology, are a type of implantable medical devices which uses electrical stimulation to treat neurological disorders. These devices are widely used to treat neurological diseases such as Parkinson, Movement disorders.

An AI enabled algorithm for detecting excessive and abnormal brain cell activity for Epilepsy attack, is a research for detection of abnormal brain cell of Epilepsy to check their epilepsy condition on the base of past history. It will check weather a person is epileptic or not, and is also determine future possibilities of having epilepsy on the base of their EEG.It is an Neural network supported algorithm to check person's Epileptic condition by examining online and offline classified data.

II. BACKGROUND THEORY

2.1Internet of Things(IOT)

In the new era of communication and technology, the explosive growth of electronic devices, smart phones and tables which can be communicated physically or wirelessly has become the fundamental tool of daily life.The next generation of connected world is internet of things (IOT) which connects devices, sensors, actuators and much more. With the help of IOT, we connect anything, access from anywhere and anytime, efficiently access any service and information about any object. The aim of IoT is to extend the benefits of Internet with remote control ability, data sharing, constant connectivity and so on. Using an embedded sensor which is always on and collecting data, all the devices would be tied to local and global networks.

The term IoT, often called Internet of everything, was 1st introduced by Kevin Ashton in 1999 who dreams a system where every physical object is connected using the Internet via ubiquitous sensors. The IoT technology can provide a large amount of data about human, objects, time and space. While combining the current Internet technology and IoT provides a large amount of space and innovative service based on low-cost sensors and wireless communication. IPv6 and Cloud computing promote the development of integration of Internet and IoT. It is providing more possibilities of data collecting, data processing, port management and other new services.

Fig.1

The Internet of things (stylised Internet of Things or IoT) is the internetworking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"),buildings and other items-embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. In 2013 the Global Standards Initiative on Internet of Things (IoT-GSI) defined the IoT as "the infrastructure of the information society." The IoT allows objects to be sensed and/or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit.

2.2 Machine Learning (Neural Network)

Deep Neural Network (DNN), also known as deep learning, is a subset of machine learning in artificial intelligence (AI) and has drawn attention in recent years as a means for classifying data on various images, videos, and sounds at a high accuracy through a machine learning process using big data.
The AI-powered automatic classification system MNet, which utilizes DNN as a computational framework, is based on a neural network called EnvNet (end-to-end convolutional neural network for environmental sound classification) and can be trained to extract and learn features of neuroimaging signals unique to various neurological diseases from a massive amount of time-series neuroimaging data.
The team expected that the use of DNN would allow for the system to learn the characteristics of neurological diseases from many signals and classify patients with neurological diseases more accurately than conventional methods using waveforms.
With MNet, they tried to classify neuroimaging big data on 140 patients with epilepsy, 26 patients with spinal cord injuries, and 67 healthy subjects. The trained MNet succeeded in classifying healthy subjects and those with the two neurological diseases with an accuracy of over 70% and patients with epilepsy and healthy subjects with an accuracy of nearly 90%. The classification accuracy was significantly higher than that obtained by a support vector machine (SVM), a conventional general machine learning method based on waveforms (relative band powers of EEG signal). Moving forward, this technique will be used for diagnosis of various neurological diseases, evaluation of severity, prognosis, and efficacy of treatment.
"Machine learning is constantly advancing, with new techniques being developed all the time. However, no matter how much analytical methods advance, if the quality of underlying data is poor, a sharp distinction cannot be drawn. We carried out the process of machine learning by utilizing DNN, which processed big data mainly from the Osaka University Hospital Epilepsy Center.[6]
Deep Neural Networks (DNN) is used as a risk prediction model which can be extended with many hidden layers being an iterative training process. The network weights can be adjusted by minimizing the difference between the network outputs and the desired outputs. Thus the accuracy of the model can be increased by adopting this method for predictive analytics.

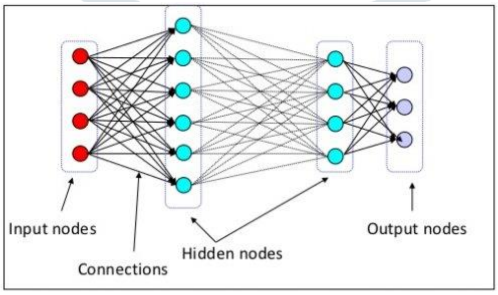

Fig.2

Deep neural networks are typically trained, by updating and adjusting neurons weights and biases, utilizing the supervised learning back propagation algorithm in conjunction with optimization technique such as stochastic gradient descent.
DNN, due to an improved technique of Transfer learning pattern recognition is done. Hence DNN can predict the risky parameters with more accuracy. the aim is to provide more accuracy and efficiency to the model [3].

2.3 Data Storage

Data storage is a general term for archiving data in electromagnetic or other forms for use by a computer or device. Different types of data storage play different roles in a computing environment. In addition to forms of hard data storage, there are now new options for remote data storage, such as cloud computing, that can revolutionize the ways that users access data.

2.4 Online and Offline Classification

In ML you use data to train a model. That model will be used to make predictions on unseen data.
In offline learning, you start with a certain amount of data. That might be a sample or it might be all of your available data. Regardless, that is all the data you'll use to train your model. Once you have a model you're satisfied with you start making predictions. Over time you'll determine that your model's performance has degraded to a point where you feel it is time to re-train your model using more/newer data and features.
In online learning you're continuously updating your models with new batches of data. You're not retraining the model as you would in offline learning, you're simply updating the model weights based on new observations.

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2.5 Arduiuno (ESP8266) :

The ESP8266 is a small WiFi module built around the ESP8266 chip that can connect your microcontroller to the internet wirelessly for a very small cost. It can be a great option for Internet of Things (IoT) projects, but can be difficult to work with for beginner hobbyists who do not have prior experience with the module. In this tutorial, we hope to show you how to interface the ESP8266 with an Arduino and perform some basic functions like connecting it to a WiFi network.

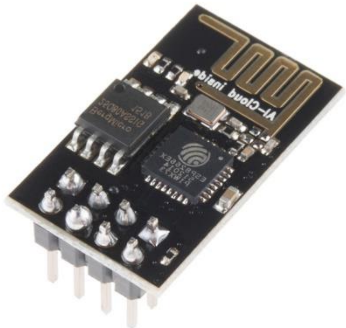


Fig.3

ESP-01 Features :

802.11 b/g/n
Wi-Fi Direct (P2P), soft-AP
Integrated TCP/IP protocol stack
Integrated TR switch, balun, LNA, power amplifier and matching network
Integrated PLLs, regulators, DCXO and power management units
+19.5dBm output power in 802.11b mode
Power down leakage current of <10uA
1MB Flash Memory
Integrated low power 32-bit CPU could be used as application processor
SDIO 1.1 / 2.0, SPI, UART
STBC, 1×1 MIMO, 2×1 MIMO
A-MPDU & A-MSDU aggregation & 0.4ms guard interval
Wake up and transmit packets in < 2ms
Standby power consumption of < 1.0mW (DTIM3)

III. METHODOLOGY AND EXPECTED OUTCOMES

3.1 Methodology

3.1.1 EEG signals / Input

Epilepsy is one of the most common neurological disorders, affecting around 1 in 200 of the population. However, identifying epilepsy can be difficult because seizures tend to be relatively infrequent events and an electroencephalogram (EEG) does not always show abnormalities. The aim of this project is to develop a new methods that could improve the diagnosis of epilepsy, leading to earlier treatment and to a better quality of life for epileptic patients. The above methods must be composed with a flexible hardware development in order to discriminate noise and bad signals from correct EEG. Even if there are EEG signal classifiers, it is suitable to perform a correct signal processing according to particular clinical reference, that is, it is difficult to have a classifier for all circumstances but it is possible to adapt EEG processing on current patient. Preliminary results are described for processing biomedical signals, namely EEG signals, in order to train the adaptive filtering in recognizing and choosing correct frequencies at which it is possible to reduce noise

3.1.2 Understanding a Signal

3.1.2.1 Balid pass filtering

BPF is a device that passes frequencies within a certain range and reject (attenuates – disambigious) for ex: “sunlight attenuates from dark glass”) frequencies outside the range

3.1.2.2 Generating power specification

While comparing specification sheets, it is quickly apparent that each generator differs between formatting and content. Basic information is available in each instance. If desired information for the generator set is not in the specification sheet, the Generator can be contacted.

3.1.3 Deep Neural Network

A deep neural network (DNN) is an artificial neural network (ANN) with multiple layers between the input and output layers. The DNN finds the correct mathematical manipulation to turn the input into the output, whether it be a linear relationship or a non-linear relationship

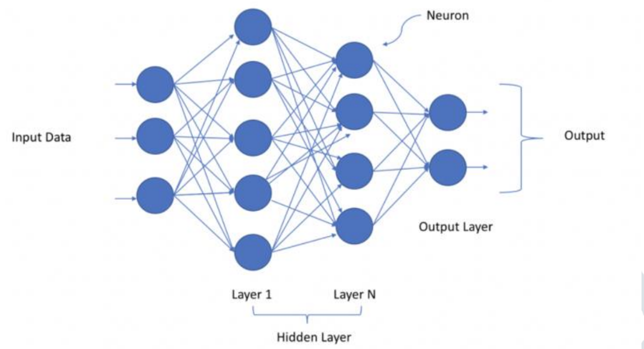


Fig.4

3.1.4 Analysis of Signal:

3.1.4.1 **Recurrent Analysis**: Process to identify a signal which generates multiple times

3.1.4.2 **Sample Entropy**: Sample entropy is a modification of approximate entropy, used for assessing the complexity of physiological time-series signals, diagnosing diseased states. SampEn has two advantages over ApEn: data length independence and a relatively trouble-free implementation

3.1.5 Classification/ NB (waves/curves) :

Naive Bayes classifiers are a collection of classification algorithms based on Bayes’ Theorem. It is not a single algorithm but a family of algorithms where all of them share a common principle, i.e. every pair of features being classified is independent of each other.

Bayes Theorem:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

Using Bayes theorem, we can find the probability of A happening, given that B has occurred. Here, B is the evidence and A is the hypothesis. The assumption made here is that the predictors/features are independent. That is presence of one particular feature does not affect the other. Hence it is called naive.

3.1.6 Pruposed Flow:

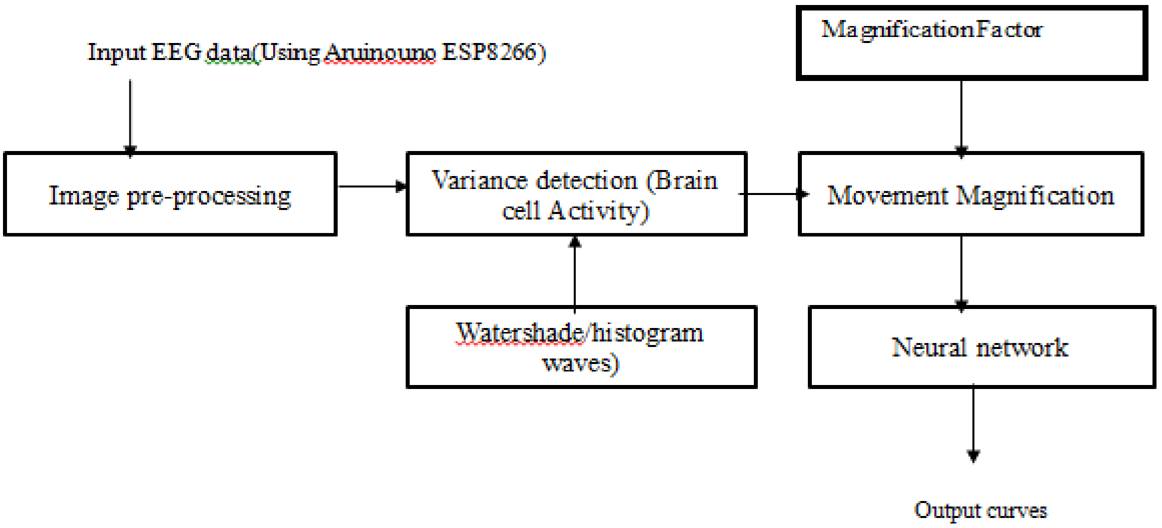


Fig.5

3.1 Expected Outcomes

Epileptic signal can be recognized in human's body on the basis of past history as well as newly generated data. Accuracy will be maintain because of Neural network to classify signal.

IV. PERFORMANCE MEASURES AND IMPLEMENTATION STRATEGIES

Which measuring parameters and implementation strategies are used is mentioned in this section.

4.1 Performance Measures

Precision, Recall and Accuracy is measured in terms of True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN).

A **true positive** is an outcome where the model correctly predicts **the positive class.**
A **true negative** is an outcome where the model correctly predicts the **negative class**.
A **false positive** is an outcome where the model incorrectly predicts the **positive class**.
A **false negative** is an outcome where the model incorrectly predicts the **negative class**.

4.1.1 Precision

For number recognition system, precision is the fraction of relevant instances among the retrieved instances. High precision means that an algorithm returned substantially more relevant results than irrelevant ones. Mathematically this can be stated as:

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}}$$

4.1.2 Recall

For number recognition system, recall is the fraction of relevant instances that have been retrieved over the total amount of relevant instances. High recall means that an algorithm returned most of the relevant results. [23] Mathematically this can be stated as:

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}}$$

4.1.3 Accuracy

Accuracy is how close a measured value is to the actual (true) value. Mathematically this can be stated as:

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}}$$

4.2 Implementation Strategies

Operating System	Ubuntu OS ,Windows OS
Programming Language	Python 3.7
Libraries	OpenCV 3.6, TensorFlow, Keras
IDE	PyCharm 3 or Sublime

Table 1

V. CONCLUSION

EG captured using AD8232 ECG module out of which was fed through 50 HZ filter and op-amp into Arduino Uno. I have used Brain Spike recorder to record and display EEG & FFT. Fast asynchronous beta waves dominate during most of the EEG trace. However, when I closed my eyes, 10 HZ slow alpha waves are seen as synchronous slow frequency waves which are larger in amplitude than of beta waves. This can be appreciated by an increase in power in 10HZ frequency spectrum.
Electrodes - you can use a normal gold plated disc electrodes and signal conditioning can be done before the actual signal goes into your controller via ADC. Amplification can be done inside the controller.
The names of the electrode sites use alphabetical abbreviations that identify the lobe or area of the brain which each electrode records from:

F = frontal
Fp = frontopolar
T = temporal
C = central
P = parietal
O = occipital
A = auricular (ear electrode)

Being able to locate the origin of electrical activity ("localization") is critical to being able to interpret the EEG tracings meaningfully.
Localizing normal or abnormal brain waves in bipolar montages is usually accomplished by identifying "phase reversal," a deflection of the two channels within a chain pointing to opposite directions.
In a referential montage, all channels may show deflections or movements in the same direction. If the electrical activity at the active electrodes is positive when compared to the activity at the reference electrode, the deflection will be downward.
Electrodes where the electrical activity is the same as at the reference electrode will not show any deflection. In general, the electrode with the largest upward deflection represents the maximum negative activity in a referential montage.
the EEGs were recorded from 64 electrodes as per the international 10-10 system (excluding electrodes Nz, F9, F10, FT9, FT10, A1, A2, TP9, TP10, P9, and P10), as shown below, which is recorded in csv format and than converted to text for coding purpose.

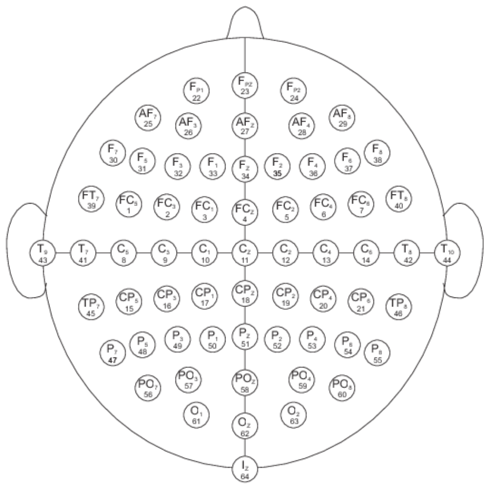
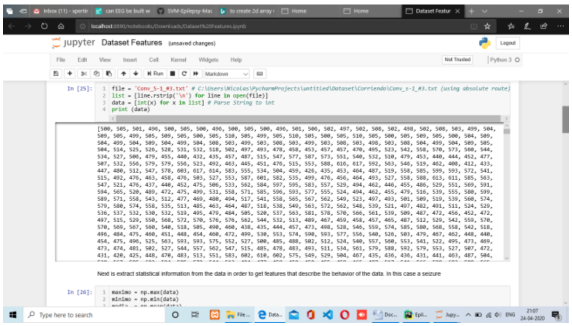


Fig.6

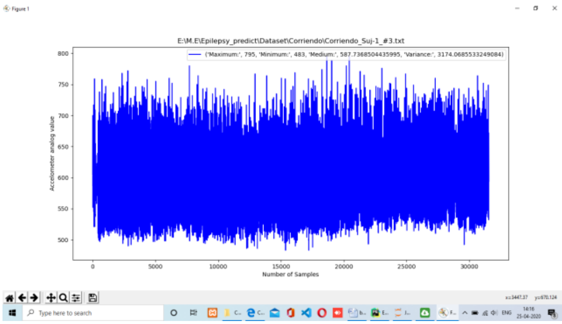
In summary, the experimental runs were:

1. Baseline, eyes open
2. Baseline, eyes closed
3. Task 1 (open and close left or right fist)
4. Task 2 (imagine opening and closing left or right fist)
5. Task 3 (open and close both fists or both feet)
6. Task 4 (imagine opening and closing both fists or both feet)
7. Task 1
8. Task 2
9. Task 3
10. Task 4
11. Task 1
12. Task 2
13. Task 3
14. Task 4

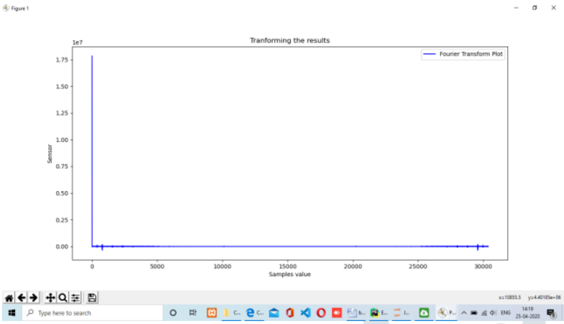
VII. RESULT OUTCOMES



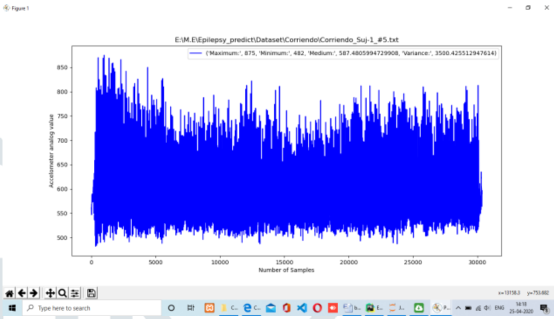
Result 1



Result 2



Result 3



Result 4

Result 5

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REFERENCES

[1] A Novel Deep Learning Strategy for Classifying Different Attack Patterns for Deep Brain Implants- https://ieeexplore.ieee.org/document/8645788

[2] IOT Based Epilepsy Monitoring using Accelerometer sensor-https://www.semanticscholar.org/paper/IOT-Based-Epilepsy-Monitoring-using-Accelerometer-Jagtap-Bhosale/248e77c2fe6e367f9a0049068430c7bb9f844292

[3] https://www.ijariit.com/manuscripts/v4i1/V4I1-1159.pdf

[4] Identify Rare Disease Patients from Electronic Health Records through Learning Approach- https://ieeexplore.ieee.org/document/8597203

[5] Heart disease prediction using machine learning techniques: a survey-https://www.ijrte.org/wp-content/uploads/papers/v8i1s4/A11740681S419.pdf

[6] Heart Attack Detection By Heartbeat Sensing using Internet Of Things : IoT-https://www.irjet.net/archives/V5/i3/IRJET-V5I3786.pdf

[7] https://ieeexplore.ieee.org/document/8533869

[8] https://www.ijirae.com/volumes/Vol6/iss03/26.SI.MRAE10105.pdf

[9] H. Rathore, ``Arti_cial neural network," in Mapping Biological Systems to Network Systems. Springer, 2016, pp. 79_96.

[10] https://arxiv.org/ftp/arxiv/papers/1801/1801.05412.pdf

[11] https://www.wikipedia.org/

[12] https://randomnerdtutorials.com/esp8266-ds18b20-temperature-sensor-web-server-with-arduino-ide/

[13] https://www.healthline.com/health/bracelets-and-devices-epilepsy